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TRANSLATION

AC-ELECTRIC ARC INSTALLATION FOR THE OBTAINMENT OF HIGH TEMPERATURE GAS FLOW

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AC-Electric Arc Installation for the Obtainment of High Temperature Gas Flow

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V. S. Pelevin

In this report is explained the nature of the phenomena ,taking place in an electric arc, and the basic principles of obtaining with the aid of an arc a high temperature gas flow. A detailed description is given of the device and its construction. Operational parameters of aggregates are listed.

One of the sources, which can assure the obtainment of high temperatures for a lasting period of time , is the high intensity electric arc.

For the electroarc thermal process is very important the obtainment of high volumetric density of thermal energy, i.e. amount of heat, forming in unit of volume per unit of time.

At present time there are no reliable methods of measuring high temperature in an arc discharge. Consequently its value can be determined by the magnitude of light brightness.

It is known, that to obtain high brightness of arc discharge and correspondingly a high temperature it is necessary that the electric e ergy should flow into the electric arc channel in possibly greater amount per unit of time. However, as was shown by [1-3] , an increase in the amount of energy going into the open arc discharge leads to an increase in brightness only up to a specific limit. The latter depends particularly, upon the type of gas, in the atmosphere of which is situated the arc discharge.

It is shown by [4], that the temperature of an open arc discharge does not depend upon the amount of energy, going within a unit of time, and that the power liberated within unit of volume of an arc discharge also grows only to a known maximum.

It is shown in much earlier reports [5-7] that the current density in an open arc discharge reaches maximum value, whereby the rise in amperage leads to a rise in transverse section of the arc , and the current density remains unchanged. Initial efforts in solving the problem of increasing the brightness of a simple carbon arc enabled to determine, that to increase the luminosity of an anode crater and protect same against intensive scorching it was necessary to prevent transition of the discharge from the face of the anode to its side surface. For this purpose in the first constructions of high intensity arc lamps at the time of arc burning the arc flame along the anode was gulled with acetylene , illumination gas, air etc. But the application of this method led to no desired results.

To raise gas density in the arc gap was found to be very effective the use of thermal and magnetohydrodynamic effects, without having to resort to high pressures in the arc chamber.

One of the methods, used in increasing gas density with simultaneous increase in current density in the arc gap appears to be compression of arc discharge shaft. The latter, in particular, is attained by the evaporation of water on account of heat transfer by the outer layers of the arc discharge shaft (arc discharge core). Cooling of surface layers reduces ionization, and consequently, the electric conductivity of the gas on the outer surface of the gas discharge. This leads to a reduction in the cross section of arc core, to a rise in current density and liberated energy, which in turn leads to a rise in temperature. The achievement of greater current density produces the arc core compression effect by the natural magnetic field of arc current. The radially directed compressive force is directly proportional to the square of amperage and inversely proportional to the square of arc core radius.

This compressive force acts not only in radial, but also in axial directions. The pressure along the axis of arc is transmitted to the electrode. Having no special siginificance for the face of the electrode, it exerts its effect against the core of the arc.

In this way, in the central part of arc core, two simultaneously acting opposite effects are present: on one hand, high temperature in the central part of arc core, causing a reduction in gas density along its axis, and on the other haned - the effect of magnetic compression, raising gas density.

Both these effects under specific conditions promote an increase in axial forces, which is necessary to lead out high temperature gases from the arc gap. It is mentioned in report [4], that at a too high or too low limitation of the arc core its temperature and brightness decrease. It was established, that an increase in energy introduced into an arc discharge channel lead at first to a rise in brightness and temperature. But as the introduced energy is being increased (ratio of increase) its rise is slowed down.

This is the essence of phenomena, taking place in an electric arc.

To make use of an electroarc discharge was developed an arrangement and a special installation was assembled, allowing to carry out a series of laboratoty investigations. The construction of the installation offers the possibility of creating various conditions for the performance of functions:

1) at an atmospheric pressure in the antechamber with outflow of high temperature stream into the pressure chamber with various vacuum in it;

2) at a different excess pressure in the antechamber with outflow of a stream into the pressure chamber at a different vacuum in it.

To produce pressure in the antechamber it is possible to use compressed air or other gases.

A schematic drawing of the installation is shown in fig.1. Its basic components are:

pressure chamber I, antechamber II, arc chamber III, disk type electrode IV, mechanism for automatically feeding the electrode V, electric solenoid coil VI, magnet with shifting mechanism VII.

Inspection windows VIII are provided for observation, these windows are situated on three sides along the circumference of the pressure chamber. To assure the possibility of carrying out assembling operations in the interior of the pressure chamber there is an airtight hatch IX.

Excess pressure in the antechamber is produced on account of introducing compressed air or inert gases. The lead-in of air is realized over an annular duct of a special stuffing box with further lead out through a conical adapter and flow around an electrode rod, passing through the internal surface of conical adapter. This allows for simultaneous cooling of the electrode rod.

The magnitude of pressure in the antechamber is controlled by valve XV. When necessary the surplus pressure in the antechamber is released through a pipe line and valve XVI into a vacuum line or into the atmosphere through valve XVII. To operate the antechamber at an atmospheric pressure valve XVII must be open.

Rarefaction in the pressure chamber is produced with the aid of vacuum pumps. Rough control of rarefaction value is realized with the aid of slide gates XXII. Precision control is realized with a needle valve X, situated on the panel of the control desk. At the point where the pressure chamber is connected with the vacuum line is situated filter XI to cleanse discharge gases from mechanical dust, having a harmful effect on the operation of vacuum pumps.

To produce the necessary working condition of the installation there is the possibility of changing a number of parameters by valve control: of vacuum system, lines for creating pressure in antechamber, lines for water cooling the arc chamber and disk electrode.

The delivery of electric energy and carbon electrode is controlled automatically with the aid of a special mechanism. All instruments for controlling and adjusting

the working process of the installation are mounted on the control panel XIV.

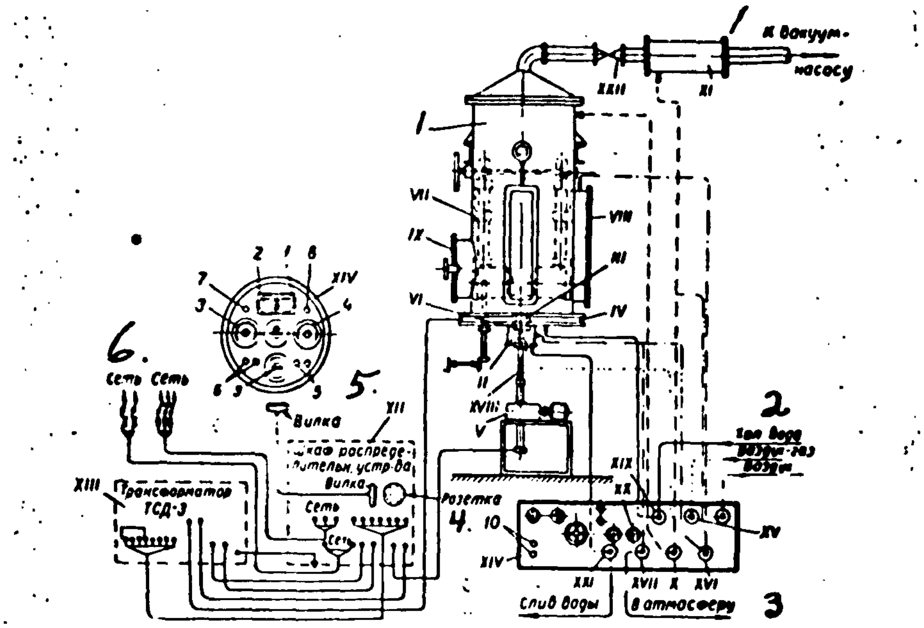

Fig.1.Schematic drawing of the AC installation with combined flow stabilization 1-to vacuum pump; 2-cooling water,air-gas, air; 3-drainage of water into the at mosphere; plug in (4); 5-fork-distribution box-fork; network, network; 6- network network, Transformer TSD-3

The installation operates on AC current with a voltage of 220 v with water stabilization of the arc current. Delivery of electric energy to the installation is realized from a power cable through two arc type welding transformers XIII.

Automatic control of electric current value during the operation of the arc chamber is realized with the aid of the following aggregates:

1) special reductor V;
2) distributor box XII;
3) welding transformers TSD-1000-3 XIII;
4) control desk XIV.

The special reductor is intended for automatic adjustment in the rate of feeding the carbon electrode depending upon the given parameters of the current on the electrodes.

In the box of the distrubution device are situated an apparatus and equipment included in the automatic control circuit.

The arc is fed AC current with a frequency of 50 c.

The commutation circuit of the transformers allows to control the current and voltage in two ways. At a constant amperage of 12[illegible] amp the voltage on the terminals of the electrodes can be changed from 20 to 160 v and, vice versa, at a constant voltage of 80 v it is possible to change the amperage within limits of from 400 to 2400 amp.

On the electric control desk are mounted the following electro measuring instruments: ammeter 1 and voltmeter 2 to measure current and voltage on the arc; potentiometer 3 to control arc voltage; potentiometer 4 to control rate of feeding the carbon electrode; buttons 5 "higher ", "lower", for remotely controlling the current on the arc; buttons 6 to shift the carbon electrode up or down; button 7 for starting button 8 for stopping operation of the automat; switch 9 for swirching over reductor from operating condition into idling.

The electric automatic control circuit is realized by the principle of automatically controlling the rate of feeding the carbon electrode in dependence upon the given arc voltage. For this purpose the generator, feeding the motor of special reductor, in addition to the compound and independent windings, has an additional arc winding, cut in through a selenium rectifier to the terminals of the electrodes.

During the operation of one independent winding the reductor motor feeds the carbon electrode upwards. During operation of one of the arc windings the reductor motor turns in other direction and lower the carbon electrode downwards. During operation of the arc both windings produce a resultant stream, dictating the magnitude of voltage and the polarity of the generator , and consequently, the rate and direction of rotation of the motor of the reductor. Thanks to such a dependence the rate of feeding the carbon electrode changes with the change in voltage on the terminals of arc electrodes, whereby the rate of feeding the electrode is equal to the rate

of its burning up.

The current value (amperage) of the arc is set by buttons 10 " higher ", "lower" which change the operation of the welding transformer in accordance with the current indicator on the transformer. Subsequent delivery of arc current to the necessary value is done with buttons 5 by the ammeter.

When the installation functions with water stabilization the electric arc discharge, originating between the movable carbon electrode XVIII, having the form of a round rod, and the stationary disk type electrode IV in form of a bushing with opening for outlet of high temperature stream, is connected to arc chamber III. The axis of the cylindrical arc chamber coincides with the axis of the movable carbon electrode and with the axis of disk electrode bushing opening. On the inner cylindrical surface of the arc chamber is tangentially fed water for cooling. The disk electrode is cooled with water passing over its inner annular surface.

Having passed the annular cavity of the disk electrode, the cooling water travels over radial channels toward the center in the outer annular shell of arc camera. Next through special openings the water flows into the internal hollow of arc chamber. Introduction of water along the tangent to the former of the chamber creates a rotating water layer (jacket), moving along the wall of the chamber in direction, opposite of the opening in the disk electrode. Having reached the front of the chamber the water layer is thrown into the antechamber.

In this way, by the operation of the cooling system is attained simultaneous protection of arc chamber against burning up, cooling of both electrodes and an increase in temperature of the gas flow. The amount of water flowing for cooling the disk electrode and into the arc chamber, is controlled by valve XIX and by the indications of the pressure gage XX. Drainage of cooling water and the maintaining of the necessary water level in the antechamber is done by controlling valve XXI.

To raise the density of the gas flow, coming out from the arc cahmber into

pressure chamber, and to raise its temperature, provisions are made to aplly the magnetic compression effect. For this purpose arc chamber III is mounted so, that it appears to be situated within the electric solenoid coil. Delivering electric current to the solenoid coil is realized from a special transformer with current control within limits of from 100 to 500 amp. The intensity of the magnetic field of the solenoid changes from 300 to 1500 e.

In the interior of the pressure chamber is mounted and electromagnet, the yoke of which is the body of the chamber and special guide cores. Total weight of the yoke is about 800 kg. The delivery of electric current to the cooled solenoid coils is done from an independent transformer with current control within 200 to 700 amp. The intensity of the magnetic field in the air gap 3 cm wide can be changed from 10200 to 35700 e. The construction of the installation has provisions for the displacement of the electromagnet along the axis of the pressure chamber (along the gas flow) to a length of up to 300 mm and a change in air gap between the cores from 10 to 50 mm. The apparatus for connecting both electromagnetic devices is situated in the general control desk.

English summary follows

The basic principles of operation of an electric arc device for obtaining a high-temperature gas flow are indicated in the paper. The device, which is supplied by alternating current, is so designed that it is possible to use the experience obtained in the setting up of equipment to obtain a high-temperature gas flow over a lengthy period of time.

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